Resources for future generations – understanding earth and people

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Earth's growing population requires resources for the basics of life and increasing standards of living. Energy from many sources, numerous minerals and water are critical for human existence, and are increasingly linked in the context of sustainability. For future generations, resources must be discovered and cleanly exploited, even as efforts to improve efficiency and increase recycling continue. To succeed, we must fully understand the earth, from the critical processes that concentrate resources to the environment and climate that support life. Simultaneously, we must engage broadly with people to fully understand needs and concerns, inform effective policy, and provide the knowledge to support future generations. The Resources for Future Generations 2018 conference will bring together geoscientists, engineers, members of civil society, and young people to learn, discuss and debate these issues.

L'augmentation de la population sur terre requiert des ressources suffisantes pour satisfaire les besoins vitaux de base et l'accroissement du niveau de vie. L'énergie tirée de nombreuses sources, un grand nombre de minéraux ainsi que l'eau sont indispensables à l'existence humaine et sont de plus en plus liés au contexte du développement durable. Pour les générations futures, les ressources doivent être découvertes et exploitées proprement, même si des efforts continus contribuent à une amélioration de l'efficacité et à un recyclage croissant. La réussite passe par une totale compréhension des caractéristiques terrestres, depuis les processus incontournables de concentration des ressources jusqu'aux conditions régulant l'environnement et le climat, supports de vie. Simultanément, nous devons nous mettre pleinement à la disposition se la population, pour la compréhension totale des besoins et des inquiétudes actuelles, celle d'une politique pertinente et la diffusion des connaissances utiles aux générations futures. La Conférence (2018) concernant les Ressources pour les Générations Futures réunira géologues, ingénieurs, membres de la société civile et aussi les jeunes qui pourront ainsi apprendre, discuter et débattre à propos de ces questions.

El crecimiento de la población de la Tierra requiere recursos tanto para las necesidades básicas sus habitantes como para el incremento del nivel de vida. La energía procedente de varias fuentes, numerosos minerales y el agua son elementos críticos para la existencia humana, y están cada vez más vinculados en el contexto de la sostenibilidad. Los recursos deben descubrirse y explotarse de forma limpia para las generaciones futuras, aun cuando continúen los esfuerzos para mejorar la eficiencia y aumentar el reciclaje. Para tener éxito, debemos comprender la tierra en su conjunto, desde los procesos críticos que concentran los recursos hasta el medio ambiente y el clima que sustentan la vida. Al mismo tiempo, tenemos que involucrarnos firmemente con las personas para comprender las necesidades e inquietudes, elaborar políticas efectivas y proporcionar el conocimiento para apoyar a las generaciones futuras. La conferencia Resources for Future Generations 2018 reunirá a geocientíficos, ingenieros, miembros de la sociedad civil y jóvenes para aprender, discutir y debatir estas cuestiones.

The human population is anticipated to grow well into this century. Currently around 3 billion people lack some or all of the basic ingredients of life – clean water, sanitation, nutrition, heat or electricity – and the number without adequate resources will likely increase with population growth. Freeing these people from poverty, desperate circumstances, and lack of a meaningful future requires natural resources, particularly energy, minerals and water.

At the same time, humans increasingly and appropriately expect a clean and protected environment. The world is embracing new technologies that enhance our lives and provide alternatives for power generation and transportation that reduce greenhouse gas emissions. Delivering these technologies requires the supply of numerous minerals; extracting and processing these minerals requires energy and water, a necessity that may compete with other users.

This picture translates into increasing demand for energy, minerals and water over the coming decades, and rapid changes in demand for some commodities as new technologies emerge. How will we meet this demand in a responsible manner that attempts to satisfy global and local sustainability goals? What is the mix of technical and social challenges, and who will provide the solutions?

To address these and many related questions, geoscientists and engineers from around the world, in academia, government and industry, along with Indigenous people, policy experts, members of civil society and young people — students and early career professionals — will meet in Vancouver, Canada, in June 2018 for the Resources for Future Generations conference (***Figure 1***). The conference seeks broad engagement and a multidisciplinary effort to fully examine the nature of Earth, the distribution of resources and how new sources can be found, and the important sustainability issues related to resource extraction. We invite you to attend! For more information, see ***www.rfg2018.org*** or follow the conference on twitter ***#RFG2018***.

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Earth and natural resources

The Earth is a remarkable planet. Over its history, our planet has seen the growth and amalgamation of supercontinents, the building of mountain ranges many thousands of kilometers in length, constant

Figure 1: Resources for Future Generations conference.

delivery of massive quantities of sediment from landmasses into adjacent sedimentary basins, and occasionally, disruptive and hazardous events such as earthquakes, volcanic eruptions and violent storms. These major events are driven by plate tectonics, and some argue that plate tectonics is also the fundamental driver of life.

Perhaps not as obvious, numerous geological processes, most of which are broadly linked to plate tectonics, have moved and concentrated metals, minerals, hydrocarbons, and water to varying extents throughout Earth's history. The formation of economic concentrations of natural resources, such as mineral deposits and petroleum reservoirs, resulted from combinations of factors linked to large-scale global processes such as magmatism, sedimentation, continental collision, the presence of water, the composition of the atmosphere, and microbiological activity. At the site of concentration, local-scale processes – such as crystallization, structure, permeability, pressure and temperature, fluid-rock-mineral interaction, and erosion rate contributed to the creation and preservation of identifiable and economic resources. Understanding these processes, and the many related aspects of Earth science that underpin the way in which they operate, is critical to our ability to find natural resources and exploit them successfully.

Humans and natural resources

The concentration of metals and minerals, both by primary processes and in many cases by secondary weathering, produced deposits that were so obvious that ancient humans recognized and started to exploit them more than 10,000 years ago. From these early days, natural resources had a profound influence on human development including agriculture, trade by land and sea, and military power. Inevitably, ownership of natural resources also became a source of conflict.

In the last 250 years, the availability of natural resources, particularly energy and minerals, fueled the industrial revolution, and subsequent mass production, transportation and consumerism. While many of the resulting changes were positive for human welfare and led to improved living conditions, land disturbance and environmental degradation were commonly related to resource development.

Fast forward to the modern era where technological innovation is integrated into everything from healthcare to space travel to global communications and the shared economy. Perhaps the most exciting applications of technology involve innovations intended to create a cleaner and greener planet and redress the unintended consequences of accelerating population growth and resource extraction. The two most cited examples of major innovations related to reducing our reliance on fossil fuels are renewable energy and electric vehicles. While welcome, these rapidly evolving sectors require abundant natural resources such as copper for electric motors and turbines, lithium, cobalt and nickel for batteries, and silicon, gallium, indium, and tellurium for solar panels. It will take considerable amounts of these and other natural resources to get us through the emerging sustainability revolution. Recycling will play an increasingly important role, but a serious resource gap needs to be filled before recycling alone can meet the long-term needs of a growing population.

The availability of water has also influenced human history and has an increasing impact on the modern world. While many in the developed world take water for granted, the importance of this most vital of natural resources has become more obvious with the depletion of aquifers, climate change, and local pollution. Water is also intimately linked to the production of energy and minerals, either as key part of production processes, or as a potential carrier of contamination in effluent from active or legacy sites. The need for water in the development of natural resources may also lead to conflict with people in the region who rely on it for habitation, agriculture or recreation. In some cases, modern technology has come to the rescue, particularly in arid regions with limited available water, where the reuse of surface water, desalination or direct use of seawater for processing, and treatment of saline ground water have become important. All of these changes, however, require significant additional energy and critical materials derived from mineral resources, further reinforcing the energy-minerals-water nexus.

Challenges for natural resources

How do we meet the resource demands of the future? First and foremost, we must discover new resources, preferably those with high concentrations of the critical commodities that we need. Over the past few decades, extraction of many natural resources has become more difficult. Many current mines have lower concentrations or grades of metals and minerals than in the recent past, hydrocarbons are extracted from more complex, lower-permeability host rocks, and deeper aquifers must be tapped for water. As a result, we expend more energy, disturb more land, and spend more per unit of production than in the past.

The discovery of new high-quality, high-value deposits can reverse this trend, allow-

ing increased efficiency of extraction per unit of commodity. Making such discoveries is challenging, but recent history demonstrates that there is considerable potential for more discoveries, especially at modest depths. In spite of rapid increases in the use of all natural resources, the extractive industries have kept up with demand, and economic reserves of most commodities have remained constant (Arndt *et al*., 2017).

The odds of making new discoveries are improved when we fully understand the critical Earth processes that work separately and collectively to form and concentrate resources of different types. Furthermore, we have to translate this knowledge into new approaches, techniques, and models to decipher existing deposits, and to be able to define the areas with the greatest potential for new discoveries. Cooperation among geoscientists from many disciplines and global regions is needed to tackle this daunting task.

Discovering new natural resources is vital, but equally important is how we extract the contained material of economic importance. The extractive industries are not viewed well by many people, which is hardly surprising given past examples of poor practices, environmental damage, and limited distribution of benefits. These industries, however, have changed significantly over the last 30-40 years, and will continue to advance by using more effective technologies, reducing energy consumption, recycling water, and applying more stringent measures to reduce pollution and other detrimental impacts on the environment. More needs to be done, particularly to make resource extraction more selective by recovering a higher proportion of valuable products from less rock, by reducing the amount of waste, and by managing the waste more effectively. The drive to increase efficiency and decrease impact is greatly assisted by new materials of construction, new processes, the use of sensors, and integration of digital data for real-time decision-making. The technologies facilitating many of these changes incorporate specialty metals, and the availability of these metals from mines and other extractive sources is therefore a prerequisite.

Efficient and clean resource extraction requires a full understanding of the rocks and minerals that host the commodities of interest. Natural resources are highly variable, both within deposits and reservoirs, and between ones of the same type. Geoscientists understand natural variability and increasingly we have the tools to quantify variation at multiple scales. The challenge, however, is to communicate this knowledge to engineers of many disciplines and to project managers. Encouraging dialogue among those involved in energy, minerals and water with many different specialties will allow new approaches for evaluation, development and enhanced environmental performance to be exchanged and advanced.

Over the long term, advances in resource extraction will be built on a profound understanding of the Earth, including surface processes, water, climate and biodiversity. Geoscience and geoscientists play major roles in understanding global change, as well as assessing local and regional landscapes. This allows us to evaluate site-specific, regional, and potential cumulate impacts at a range of scales. Government geological surveys have traditionally generated regional geoscientific data, but a broader remit for understanding all aspects of landscape from rocks, to fauna and flora, and to human habitation, may become an appropriate mandate for these agencies. Ultimately, the geoscience community will need to apply knowledge at multiple scales to identify and mitigate negative consequences from resource extraction.

Natural resources and society

Geoscience integrated with engineering and environmental management clearly provides the technical underpinning for delivering resources for the future. But technical advances in resource operations have limited potential if the people who are most at risk from the extractive process see few of the benefits. The relationship of

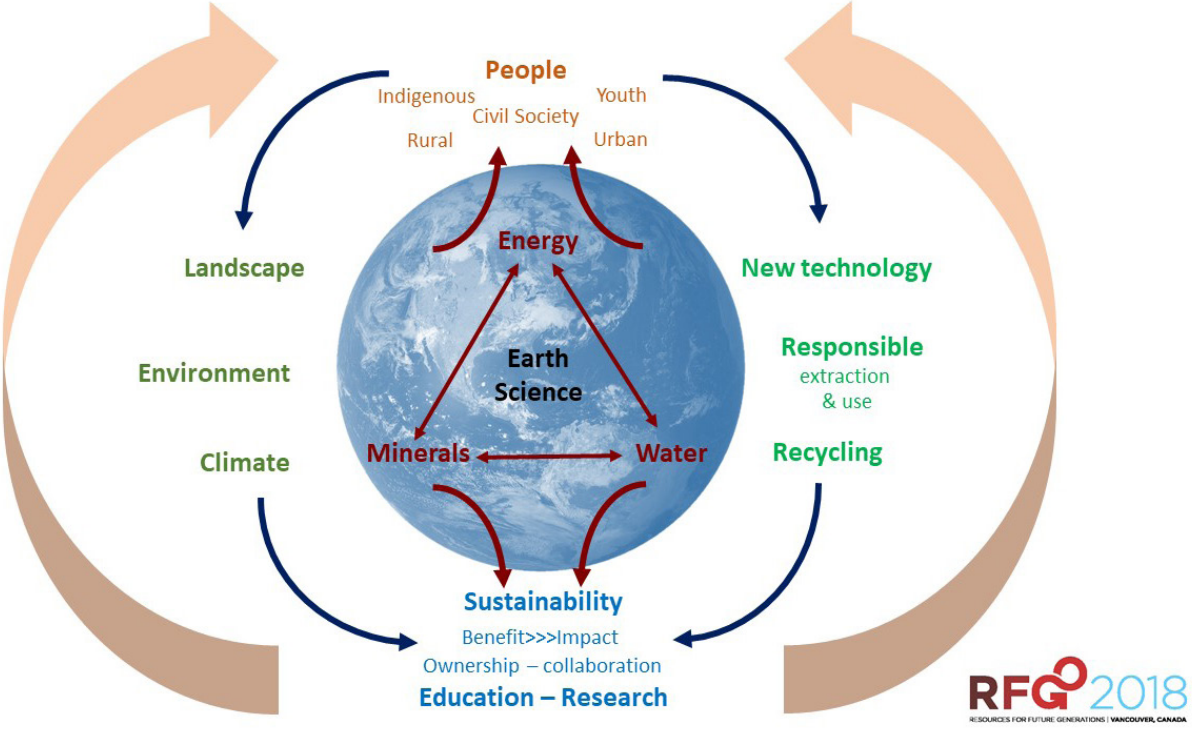

Figure 2: Interplay among energy, minerals and water, from Earth science to the needs of people and goal of sustainability.

extractive industries to society, from jurisdictions to local communities, is critical for the development of new resource projects, and increasingly involves many specialists in companies, governments and civil society. Seeking operating permits through a defined regulatory process is challenging, but achieving a social license to operate can be much harder. Failure in both these areas may ultimately have more impact on resource supply than the geological availability of resources and related discovery challenges.

Indigenous people have relationships to the land and associated resources that have evolved over time periods vastly exceeding recent industrial resource use. Understanding Indigenous knowledge and community needs is a pre-requisite for future responsible resource extraction, and while other communities do not have the same longevity, their concerns must also be heard. Successful engagement requires the interplay between the technical and non-technical world, and the interface between geoscience and engineering, and social and political science. Many technically minded people are uncomfortable bridging the gap to social science, and yet building collaboration across this divide is critical for future resource development that is designed to meet global sustainability goals.

The relationship of natural resource extraction to people living in remote settings is different to those living in cities. People in remote areas may benefit directly from resource operations. They may be employees at mines and extractive facilities, and may own related service businesses, or in some cases, a share in the operation. City dwellers are the dominant consumers of resource products, and yet they are commonly against or uninformed about resource extraction. Lack of understanding poses challenges for society when faced with complex choices. Engaging young people in the debate around natural resources, from the materials in the ground to extraction and their use in the products that they depend on daily, is critical for the future clean supply of energy, minerals and water.

RFG2018

The interplay among energy, minerals and water, from Earth science to the needs of people and goal of sustainability are depicted in ***Figure 2***. This is the context for the Resources for Future Generations – RFG2018 – conference, a global forum for discussing the future of natural resource. The conference was conceived by the IUGS – the International Union of Geological Sciences – and is being organized by several Canadian associations with support from over 40 global partners.

The conference, to be held June 16-21, 2018, will include numerous sessions covering the major technical themes — Earth, Energy, Minerals and Water — as well as nontechnical themes, including Resources & Society and Education& Knowledge. Complex and challenging issues will be debated, and efforts will be made to draw delegates from across the boundaries among the themes and disciplines. Indigenous people will demonstrate their leadership in the resource debate and will bring their unique perspective to the issues most critical for remote communities. Considerable focus will be given to young people – early career and students – who represent "Future Generations." This will include pop-up pitch sessions, career workshops, mentoring opportunities, and focus group discussions, as well as opportunities to speak in broad thematic and specific technical sessions.

Vancouver, Canada provides an excellent venue for the conference. Canada is a vast country rich in natural resources, and there is considerable national interest in the future role that resource businesses will play locally, regionally and nationally. Furthermore, Canadian companies are involved globally in all natural resources and considerable expertise resides in the country. Canada wants to be seen as an innovative leader in responsible resource development, as do many other nations with similar endowments. The conference provides a venue to develop a path forward, led by young people who will be responsible for important future decisions around the extraction and use of natural resources.

Geological processes support life, and these processes also concentrated natural resources that have aided human development for over 10,000 years, and especially in the last 250 years. It is critical that we understand this relationship, the nature of Earth in all its complexity, and the role that humans will play in maintaining the supply of critical resources while exploiting them more cleanly for the benefit of all. We must work collectively to empower future generations to take on the natural resource challenge in all its aspects. The Resources for Future Generations – RFG2018 – conference is an important step to address natural resource opportunities and challenges, and hence build a path to long-term human sustainability.

References

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